Nutrient uptake and economics of Raktasali rice variety under different seed rates and nutrient management

SK JESSIM SHA[1*], B SUDHA[2], JACOB JOHN[2], P SHALINI PILLAI[2] and SUMA DIVAKAR[1]

[1]Department of Agronomy, College of Agriculture, Kerala Agricultural University Vellayani, Thiruvananthapuram 695522 Kerala, India
[2]Integrated Farming System Research Station, Kerala Agricultural University Killipalam, Karamana, Thiruvananthapuram 695002 Kerala, India
[*]Email for correspondence: jessimshask@gmail.com

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ABSTRACT

Rakthasali, a traditional medicinal rice variety valued for its exceptional nutritional and therapeutic properties, is gradually disappearing due to the predominance of modern high-yielding varieties. Since standardized agro-techniques for Rakthasali are lacking, farmers often rely on inconsistent seed rates and nutrient management practices, leading to suboptimal performance. The present study was undertaken at the Integrated Farming System Research Station, Kerala Agricultural University, to evaluate the influence of different seed rates and nutrient management practices on nutrient uptake and economic returns in Rakthasali rice. The experiment, laid out in a factorial RBD with three seed rates (60, 80 and 100 kg/ha) and four nutrient management practices, revealed significant effects of both factors on nutrient uptake at maximum tillering, panicle initiation and harvest stages. Seed rates of 80 and 100 kg per ha recorded significantly higher and statistically comparable nutrient uptake across all stages, outperforming the 60 kg per ha seed rate. Among nutrient management practices, FYM + NPK and FYM + neem cake resulted in the maximum and statistically similar nutrient uptake, followed by PGPR-based nutrition, while neem cake + Panchagavya recorded the lowest values. Interaction effects were non-significant. Economic analysis indicated that the highest benefit-cost (B-C) ratio was achieved in 80 kg per ha among seed rates and in 5 tonnes per ha FYM + 70:35:35 kg per ha NPK among nutrient treatments, with the combination 80 kg per ha seed + 5 tonnes per ha FYM + 70:35:35 kg per ha NPK producing the highest overall B-C ratio. The study establishes that a seed rate of 80 kg per ha along with FYM + NPK application is the most efficient and economically viable strategy for enhancing nutrient uptake and profitability in Rakthasali rice cultivation.

Keywords: Rakthasali rice; nutrient uptake; seed rate; nutrient management; benefit-cost ratio

INTRODUCTION

Rice (*Oryza sativa*) is the most important staple cereal crop, sustaining nearly two-thirds of the world's population. It serves as a primary source of food and energy, with its high nutritional value making it a major component of human diets worldwide (Burlando and Cornara 2014). In India, rice plays a major role in diet, economy, employment, culture and history. It serves as the staple food for more than 65 per cent of the Indian population and contributes nearly 40 per cent to the country's total food grain production, thereby, playing a pivotal role in ensuring food and livelihood security (Pathak et al 2018). During 2023-2024, India produced 137.82 million tonnes of rice from an area of 47.83 million hectares with an average productivity of 2,882 kg per ha (Anon 2024). Rice is rich in genetic diversity, with thousands of varieties grown throughout the world and India (Priya et al 2019).

However, the rich genetic diversity is dwindling as a result of monoculture of high yielding hybrid rice varieties. Traditional rice varieties which are lauded for their health benefits should be conserved on account of their incredible health benefits including low sugar content, higher glutamic acid, fibre and vitamins. Rakthasali is one such traditional rice variety with immense medicinal value and is reported to cure fevers, ulcers and haemorrhoids as well as improve fertility, skin health and eye sight (Bhat and Riar 2015). It is

attributed with health-promoting functions such as alleviating thirst, enhancing vitality and correcting internal physiological imbalances (Kotur and Gadad 2025). Rakthasali grains are also rich in antioxidants and nutritionally important minerals like calcium, zinc and iron (Girijan 2019). Farmers growing Rakthasali are marketing grains to Ayurveda firms and are getting premium prices.

As agro-techniques are not standardised for this variety and as farmers are resorting to varied seed rates and nutrition management, an attempt to standardize the seed rate and nutrient management for Rakthasali rice was made through the present study.

MATERIAL and METHODS

The experiment was carried out at the Integrated Farming System Research Station, Kerala Agricultural University, Karamana, Thiruvananthapuram, Kerala located at 8° 28' 25" N latitude and 76° 57' 32" E longitude. The experimental site was lowland (5 m amsl).

The experiment was laid out in factorial RBD with 12 treatments, replicated thrice. There were two factors viz seed rate and nutrient management. Three levels of seed rate viz S_1 (60 kg/ha), S_2 (80 kg/ha) and S_3 (100 kg/ha) and four levels of nutrition viz N_1 {Kerala Agricultural University (KAU) package of practices recommendation for short duration rice} (5 tonnes/ha FYM + 70:35:35 kg/ha NPK), N_2 (KAU ad hoc organic recommendation for short duration rice) {5 tonnes/ha FYM + 750 kg/ha neem cake half as basal and half as top dressing at active tillering (AT) stage}, N_3 {Basal dose of 5 tonnes/ha FYM + PGPR mix 1 at AT and panicle initiation (PI) stages} and N_4 (Basal dose of 5 tonnes/ha FYM + 375 kg/ha neem cake at AT along with foliar spray of Panchagavya @ 3% at flowering and PI stages) were applied. PGPR mix 1 was applied after mixing with dried and powdered FYM (2.5:500 kg w/w) for application in one ha.

Observations were recorded on nutrient uptake and benefit-cost ratio.

RESULTS and DISCUSSION

Data in Table 1 depict that at maximum tillering, S_2 (80 kg/ha seed) and S_3 (100 kg/ha seed) resulted in 49.30 and 49.26 kg per ha nutrients uptake respectively and were at par, as compared to 41.55 kg per ha nutrients uptake in S_1 (60 kg/ha seed). This trend continued at panicle initiation stage and harvest stages also. At panicle initiation 14.18 and 13.73 kg per ha nutrients uptake was recorded in S_2 and S_3 respectively, which were at par, as compared to 11.96 kg per ha uptake in S_1. At harvest, 46.25 and 46.81 kg per ha nutrients uptake was recorded in S_2 and S_3 respectively, the two treatments being at par, compared to 39.46 kg per ha in S_1.

At maximum tillering, N_1 (5 tonnes/ha FYM + 70:35:35 kg/ha NPK) (49.22 kg/ha) and N_2 (5 tonnes/ha FYM + 750 kg/ha neem cake) (48.52 kg/ha) resulted in maximum nutrients uptake and were at par, followed by N_3 (5 tonnes/ha FYM + PGPR mix 1 at AT and PI) (46.32 kg/ha) and N_4 (5 tonnes/ha FYM + 375 kg/ha neem cake + Panchagavya @ 3%) (42.75 kg/ha). At panicle initiation, N_1 (14.11 kg/ha) and N_2 (13.87 kg/ha) resulted in maximum uptake and were at par as compared to N_3 (12.80 kg/ha) and N_4 (12.32 kg/ha), the latter two being at par. At harvest also N_1 (46.58 kg/ha) and N_2 (45.77 kg/ha) exhibited maximum uptake and were at par, however, N_2 was at par with N_3 (44.27 kg/ha). The lowest uptake was recorded in N_4 (40.09 kg/ha).

There was no interaction effect of seed rate and nutrition on the nutrients uptake.

Among seed rate treatments, the highest B-C ratio was recorded in S_2 (1.46) followed by S_3 (1.41) and S_1 (1.39). On the other hand, among nutrition treatments, N_1 (1.53) recorded the highest B-C ratio followed by N_3 (1.49), N_2 (1.34) and N_4 (1.32). In case of interaction effect, the highest B-C ratio (1.60) was observed in S_2N_1 (80 kg/ha seed + 5 tonnes/ha FYM + 70:35:35 kg/ha NPK) followed by S_2N_3 (80 kg/ha seed + 5 tonnes/ha FYM + PGPR mix 1 at AT and PI), S_3N_1 (100 kg/ha seed + 5 tonnes/ha FYM + 70:35:35 kg/ha NPK) and S_3N_3 (100 kg/ha seed + 5 tonnes/ha FYM + PGPR mix 1 at AT and PI) with 1.50 B-C ratio each.

Thus nutrient uptake increased significantly with higher seed rates. S_2 (80 kg/ha) and S_3 (100 kg/ha) consistently recorded higher and statistically at par nutrient uptake at maximum tillering, panicle initiation and harvest stages compared to S_1 (60 kg/ha). Among nutrient management practices, N_1 (FYM + NPK) and N_2 (FYM + neem cake) showed the highest and statistically similar nutrient uptake across all stages, followed by N_3, while N_4 recorded the lowest values.

Table 1. Effect of seed rate and nutrient management on nutrient uptake and B-C ratio

Treatment	Nutrient uptake (kg/ha) at			B:C
	MT	PI	Harvest	
Seed rate (kg/ha)				
S_1(60)	41.55	11.96	39.46	1.39
S_2(80)	49.30	14.18	46.25	1.46
S_3(100)	49.26	13.73	46.81	1.41
SEm	0.38	0.31	0.56	0.02
$CD_{0.05}$	1.131	0.923	1.646	0.004
Nutrition				
N_1 (5 tonnes/ha FYM + 70:35:35 kg/ha NPK)	49.22	14.11	46.58	1.53
N_2 (5 tonnes/ha FYM + 750 kg/ha neem cake)	48.52	13.87	45.77	1.34
N_3 (5 tonnes/ha FYM + PGPR mix 1 at AT and PI)	46.32	12.80	44.27	1.49
N_4 (5 tonnes/ha FYM + 375 kg/ha neem cake + Panchagavya @ 3%)	42.75	12.32	40.09	1.32
SEm	0.44	0.36	0.64	0.02
$CD_{0.05}$	1.307	1.066	1.900	0.005
Interaction effect (seed rate × nutrition)				
S_1N_1 (60 kg/ha seed + 5 tonnes/ha FYM + 70:35:35 kg/ha NPK)	44.88	12.43	41.60	1.49
S_1N_2 (60 kg/ha seed + 5 tonnes/ha FYM + 750 kg/ha neem cake)	42.28	12.42	41.04	1.28
S_1N_3 (60 kg/ha seed + 5 tonnes/ha FYM + PGPR mix 1 at AT and PI)	40.69	11.79	39.01	1.48
S_1N_4 (60 kg/ha seed + 5 tonnes/ha FYM + 375 kg/ha neem cake + Panchagavya @ 3%)	38.36	11.06	36.22	1.30
S_2N_1 (80 kg/ha seed + 5 tonnes/ha FYM + 70:35:35 kg/ha NPK)	50.89	15.23	49.04	1.60
S_2N_2 (80 kg/ha seed + 5 tonnes/ha FYM + 750 kg/ha neem cake)	52.28	14.67	47.90	1.41
S_2N_3 (80 kg/ha seed + 5 tonnes/ha FYM + PGPR mix 1 at AT and PI)	48.67	13.54	45.83	1.50
S_2N_4 (80 kg/ha seed + 5 tonnes/ha FYM + 375 kg/ha neem cake + Panchagavya @ 3%)	45.38	13.28	42.26	1.33
S_3N_1 (100 kg/ha seed + 5 tonnes/ha FYM + 70:35:35 kg/ha NPK)	51.89	14.68	49.10	1.50
S_3N_2 (100 kg/ha seed + 5 tonnes/ha FYM + 750 kg/ha neem cake)	51.01	14.53	48.37	1.32
S_3N_3 (100 kg/ha seed + 5 tonnes/ha FYM + PGPR mix 1 at AT and PI)	49.59	13.08	47.98	1.50
S_3N_4 (100 kg/ha seed + 5 tonnes/ha FYM + 375 kg/ha neem cake + Panchagavya @ 3%)	44.53	12.64	41.80	1.33
SEm	0.77	0.63	1.12	0.03
$CD_{0.05}$	NS	NS	NS	0.009

MT = Maximum tillering, PI = Panicle initiation, AT = Active tillering, PGPR = Plant growth-promoting rhizobacteria, FYM = Farmyard manure

No significant interaction was observed between seed rate and nutrient management. In terms of economics, the highest B-C ratio was obtained with S_2 among seed rates and N_1 among nutrient treatments. The combination S_2N_1 produced the highest overall B-C ratio.

CONCLUSION

The investigations demonstrated that both seed rate and nutrient management exerted a considerable influence on nutrient uptake and economic returns in Rakthasali rice. Seed rates of 80 kg per ha (S_2) and 100 kg per ha (S_3) consistently enhanced nutrient uptake at all growth stages, with both treatments remaining statistically at par and distinctly superior to the lower seed rate of 60 kg per ha. Among nutrient management practices, the application of FYM + recommended NPK dose (N_1) and FYM + neem cake (N_2) proved most effective in improving nutrient uptake, while the combination involving neem cake and Panchagavya (N_4) performed the least. Although the interaction between seed rate and nutrient management was not significant, the economic analysis clearly highlighted S_2N_1 (80 kg per ha + FYM + NPK) as the most profitable combination, recording the highest B-C ratio. Overall, the study underscores that adopting an 80 kg per ha seed rate coupled with balanced FYM and NPK

fertilization is a practical, efficient and economically rewarding agro-technique for cultivating the nutritionally and medicinally important Rakthasali rice variety.

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